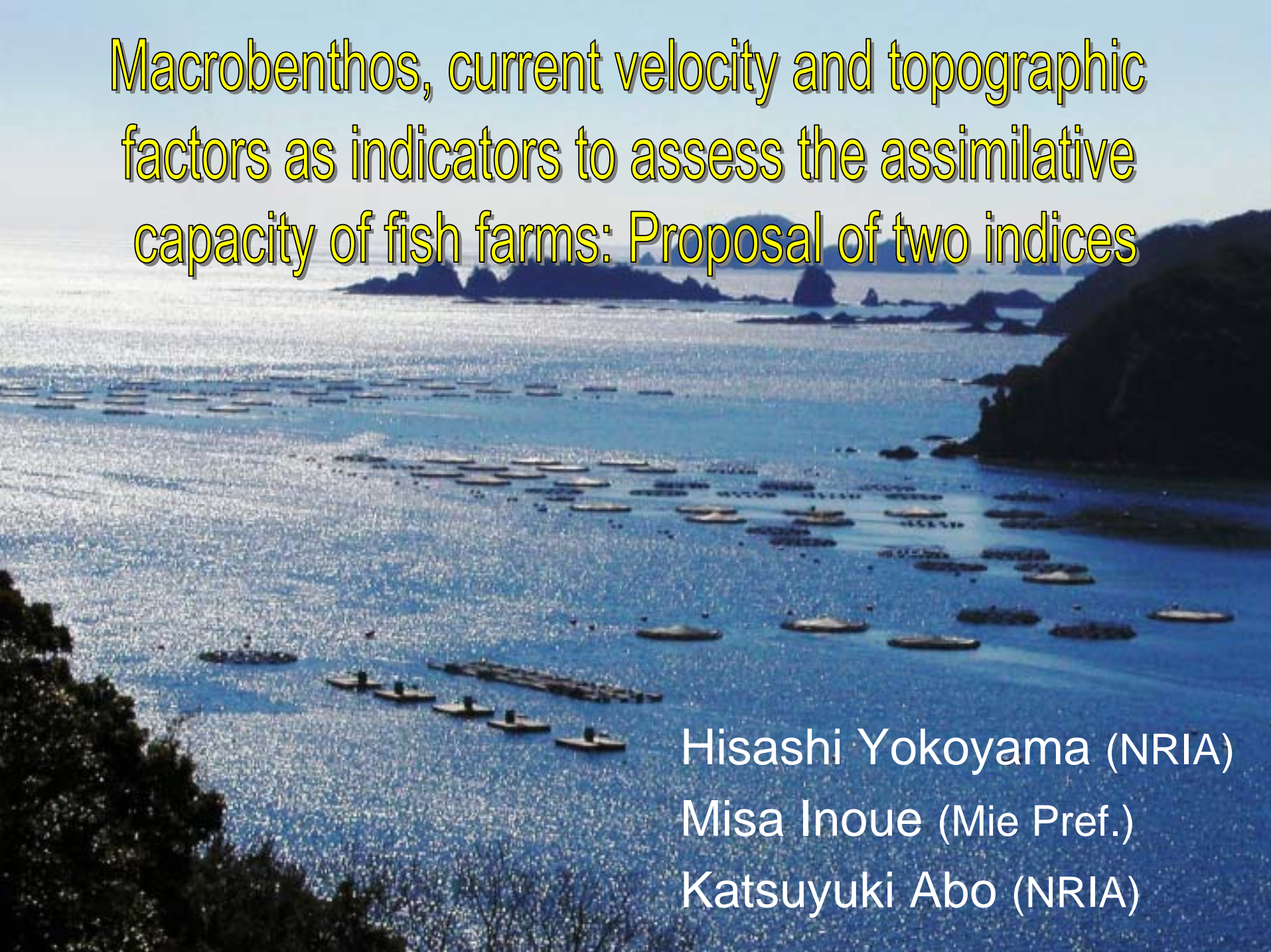


Macrobenthos, current velocity and topographic factors as indicators to assess the assimilative capacity of fish farms: Proposal of two indices

An aerial photograph of a coastal area with a large fish farm. Numerous rectangular floating cages are visible in the blue water, arranged in rows. The coastline is visible on the right and bottom left, with some greenery. In the background, there are more islands and a clear sky.

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To maintain sustainable aquaculture, it is necessary to assess farm environments objectively, and to conduct cultivation within the range of the assimilative capacity, which is defined as the ability of an area to maintain a 'healthy' environment and 'accommodate' wastes.

Objective of our study

How can we know the assimilative capacity?

We tried to develop a convenient and simple way to estimate the assimilative capacity by fish farmers themselves.

Fundamental concept

Assimilative capacity is determined by waste dispersal and oxygen supply

Hypothesis 1

Waste dispersal and oxygen supply are influenced by topographic conditions

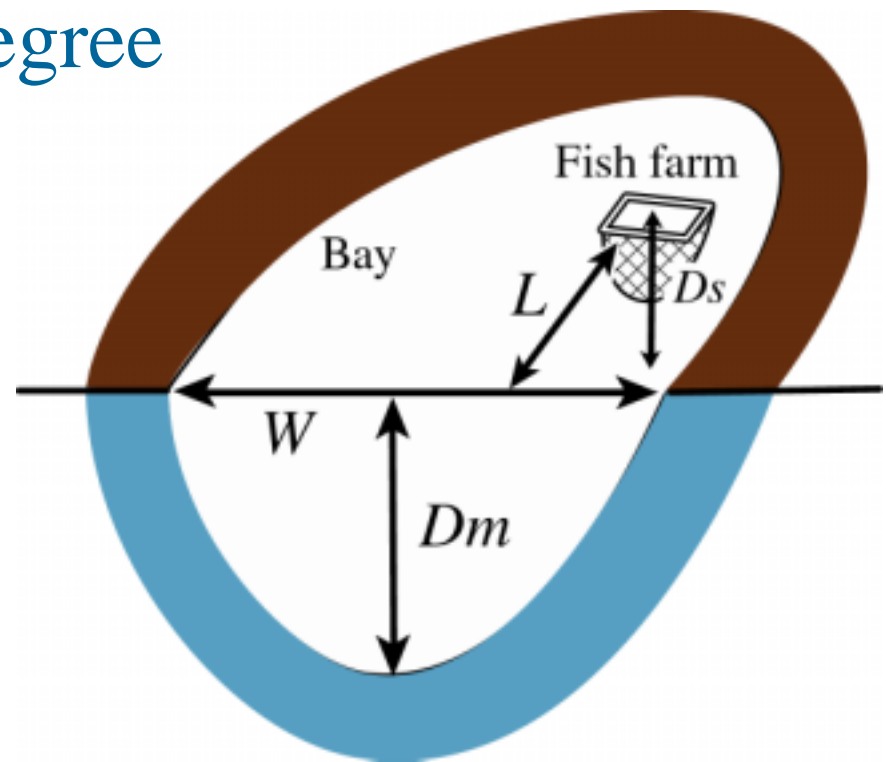
Hypothesis 2

Waste dispersal and oxygen supply are influenced by water depth and current velocity

Proposal of an index of topographic conditions

ED: Embayment Degree

$$ED = \frac{L}{W} \times \frac{45}{Dm} \times \frac{20}{Ds}$$



Offshore, deeper area ➡ smaller value
inshore, shallower area ➡ larger value

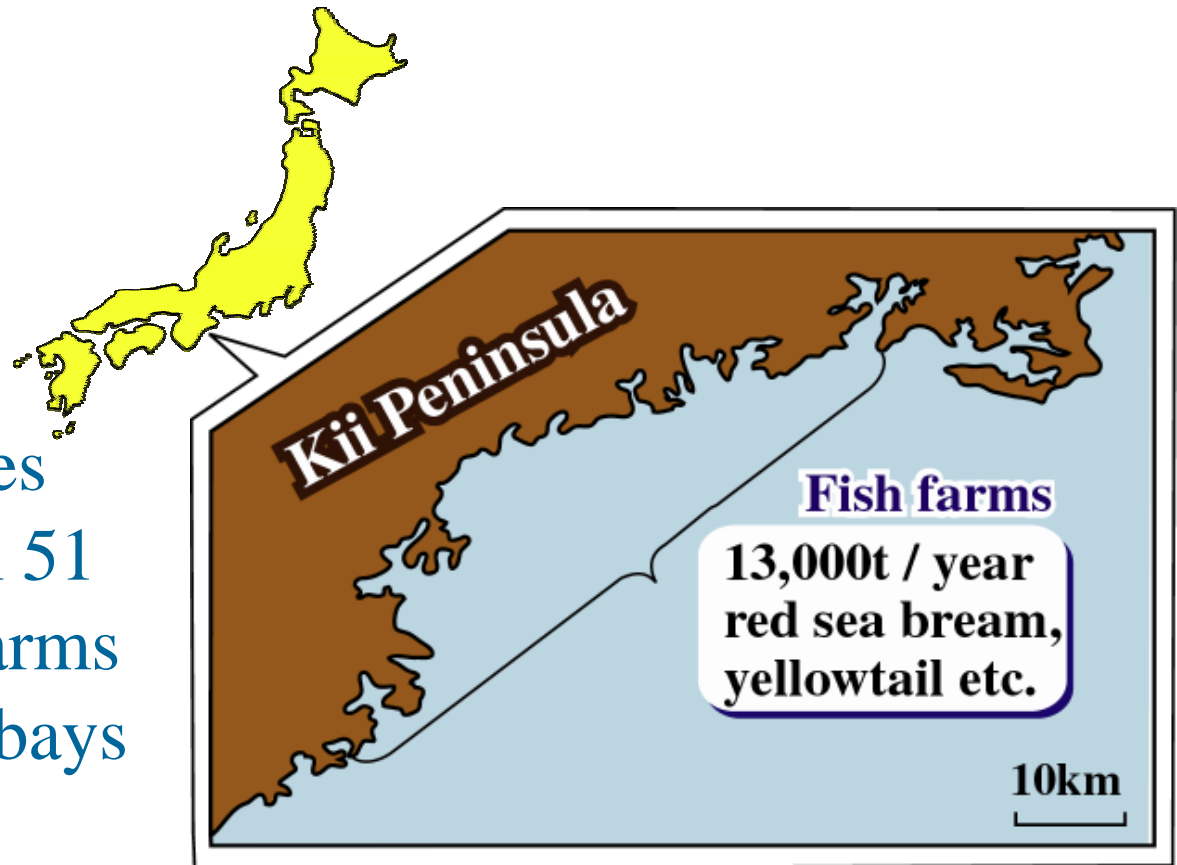
Macrofauna reflects fish-farm environments.

Is macrofauna determined in the gradients of fish production and ED?

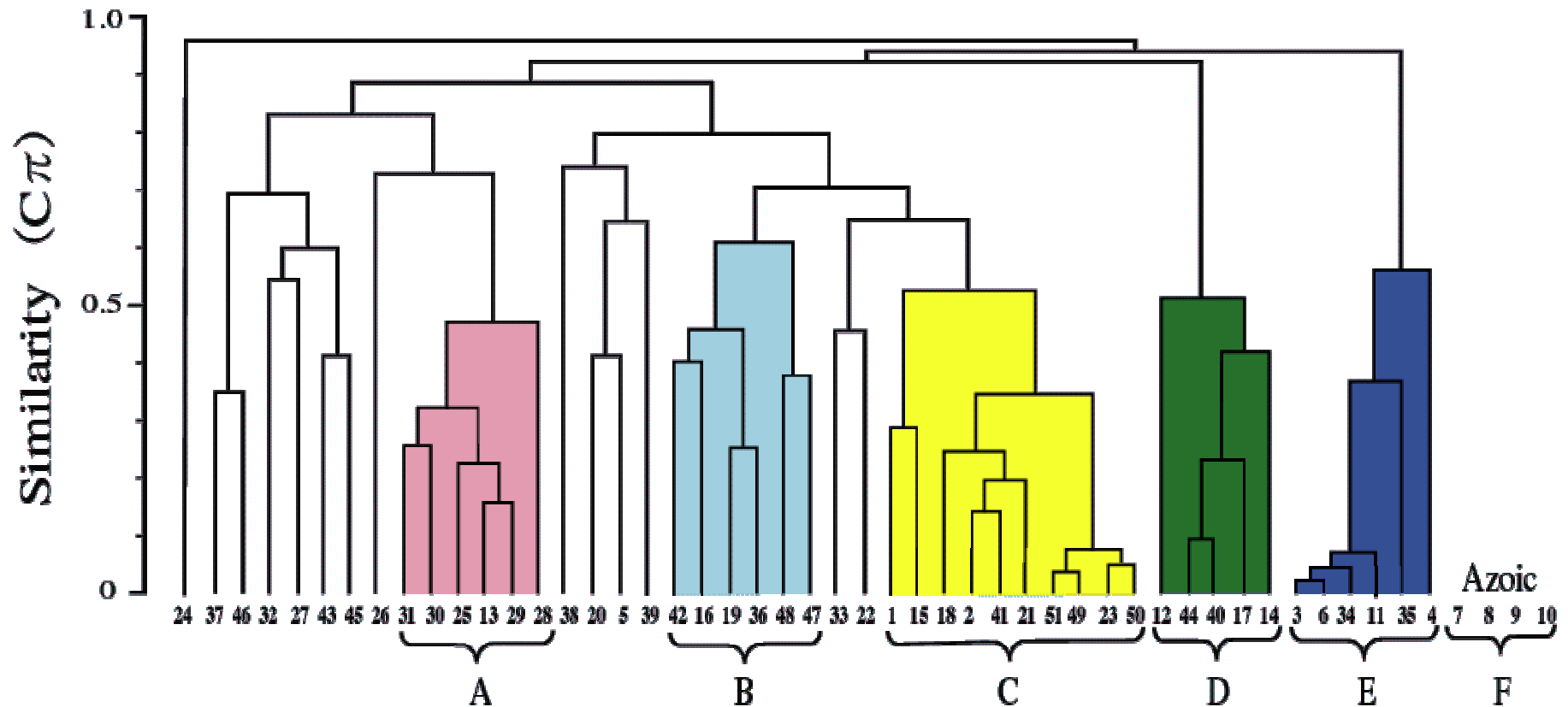
If the answer is yes, hypothesis 1 and usefulness of ED will be proved.

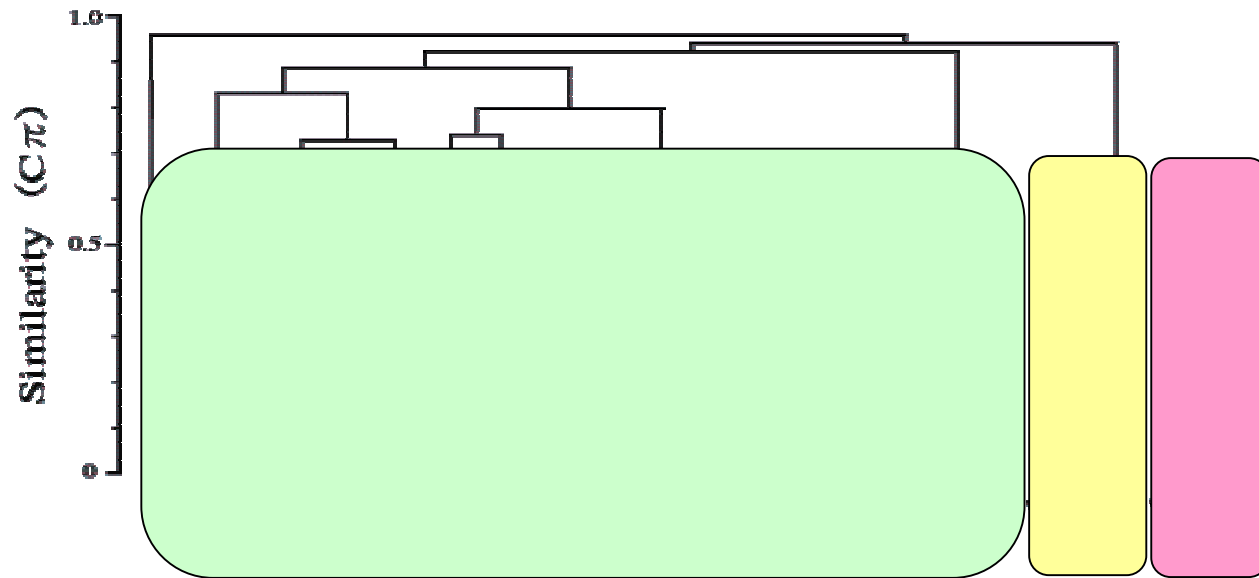
We examined macrofauna in fish farms
along the coast of Kumano-nada

Macrofaunal samples
were collected from 51
stations at 22 fish farms
located in 10 small bays
during a period of
August-September.



We found 5 assemblages and 4 azoic stations based on the cluster analysis of the macrofauna

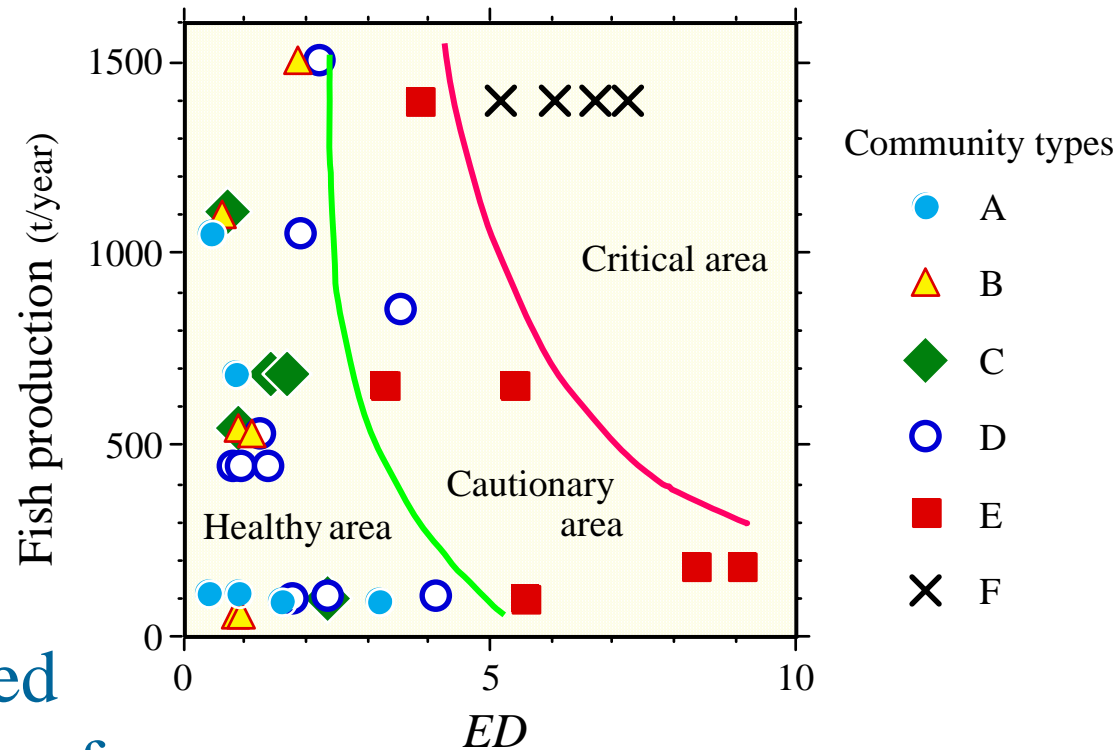




Assemblages are classified into 3 groups:

- A, B, C and D are characteristic of a healthy zone
 - • • high diversity, saturated DO & unenriched sediments
- E is characteristic of a cautionary zone
 - • • pollution indicator species, small biomass, low density, hypoxia & enriched sediments
- F is characteristic of a critical zone
 - • • azoic conditions, anoxic & highly enriched sediments

Assemblages in the gradients of fish production and ED



Three groups are arranged
regularly in the gradients of
fish production and ED, indicating that

- ★ both fish production and topographic conditions affect environments and macrofauna,
- ★ ED is a good index of topographic conditions.

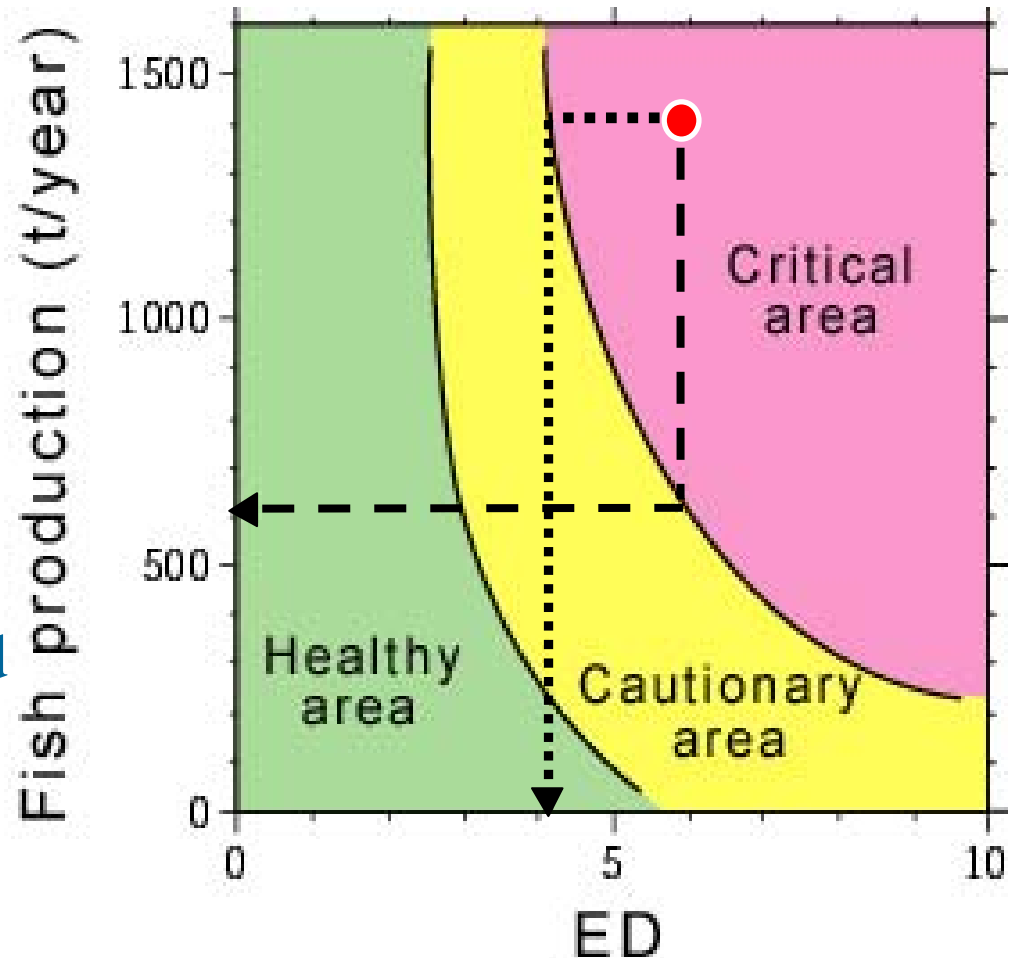
Use of ED for suitable siting

Suitable siting for fish farming and upper limit of fish production can be estimated.

In case a fish farm with 1400 t /year is located in the critical zone with ED of 6,

★ this farm should be shifted to the area with ED of <4 , or

★ annual production should be lowered to <600 t.



ED is a good index for site selection of fish farms.

However,
it is unknown whether ED is applicable to all
localities under variable topographic and
oceanographic conditions.

We propose another index based on hypothesis 2
(Waste dispersal and oxygen supply are influenced
by water depth and current velocity).

Proposal of ISL

Water depth (D) and current velocity (V) are more direct variables that control waste dispersal and oxygen supply.

Based on these parameters,

We propose **ISL** (Index of **S**uitable **L**ocation for fish farms).

$$\begin{aligned} \text{ISL} &= DV^2 \\ &= \boxed{DV} \times \boxed{V} \Rightarrow \text{oxygen supply} \\ &\quad \downarrow \\ &\quad \text{waste dispersal} \end{aligned}$$

Use of plaster balls

To compare the current velocity among stations, it is necessary to measure velocities at the same time.

An electromagnetic current meter is expensive.

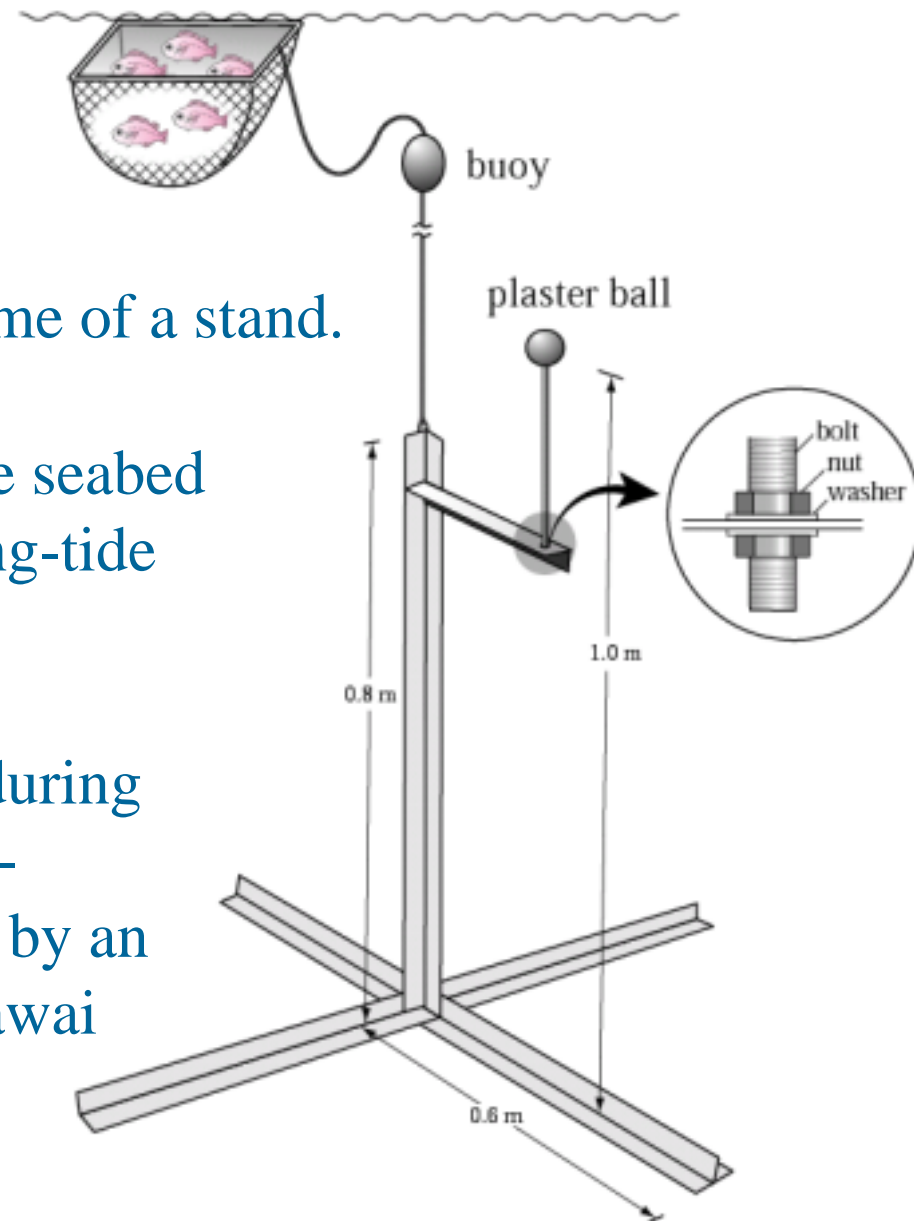
We used plaster balls as a convenient device to estimate the current velocity, because there is a positive correlation between the intensity of water motion and the weight loss of plaster balls (Komatsu & Kawai 1992).

Plaster-ball survey

A plaster ball was fixed on the frame of a stand.

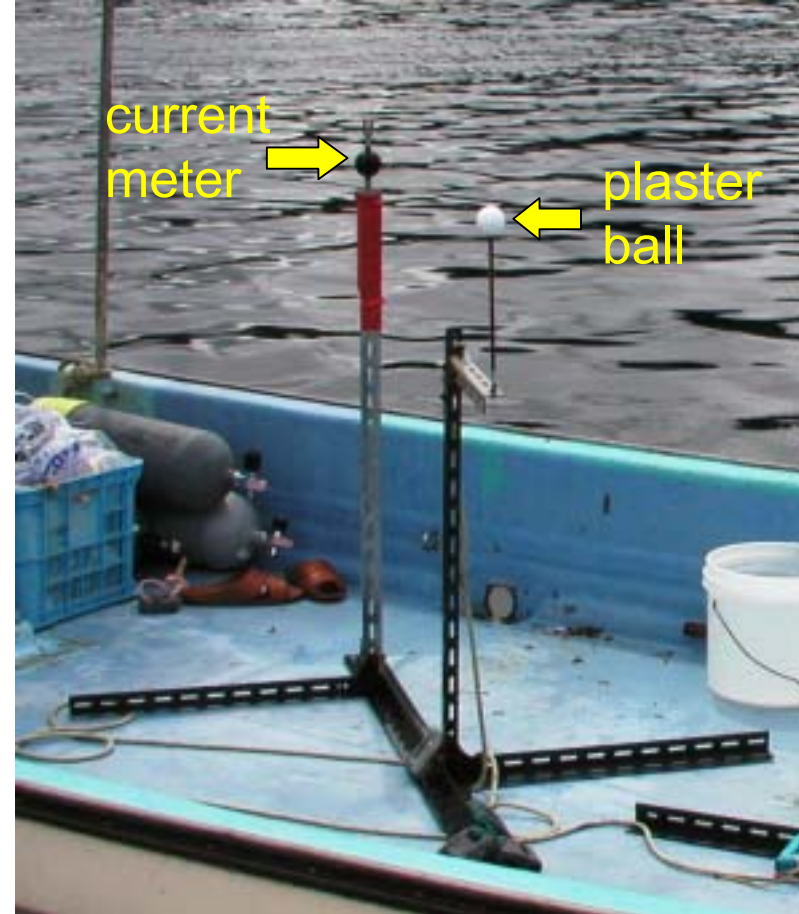
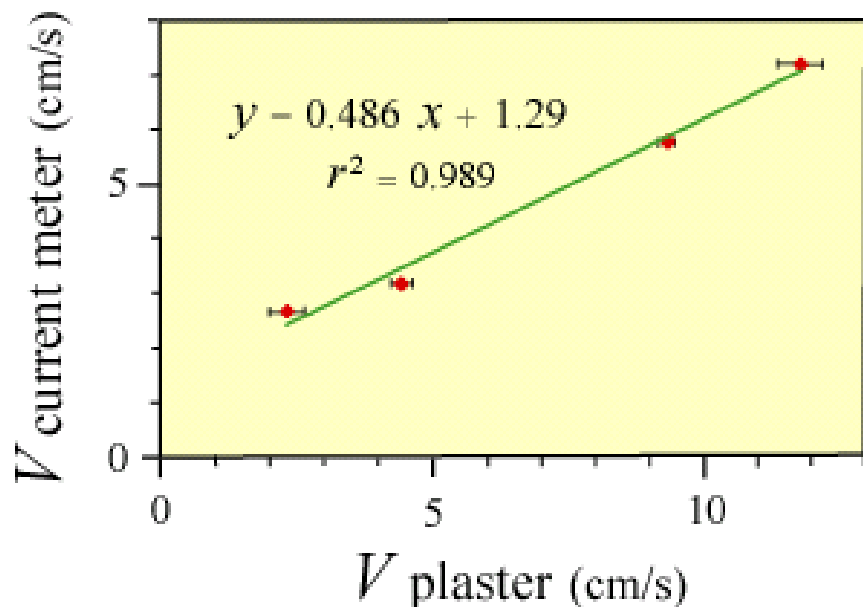
Stands were set above 1 m from the seabed for 50 hours during neap- and spring-tide periods.

We measured the wet weight loss during immersion, and calculated the time-averaged intensity of water motion by an equation given by Komatsu and Kawai (1992).



Verification by a current meter

We examined the relationship between the values determined by the plaster-ball method (Komatsu and Kawai, 1992) and actual current velocities measured by a current meter.



The result indicates that current velocity can be estimated through the correction of the equation presented by Komatsu & Kawai.

Equation to estimate current velocity

Wet weight loss of a plaster ball

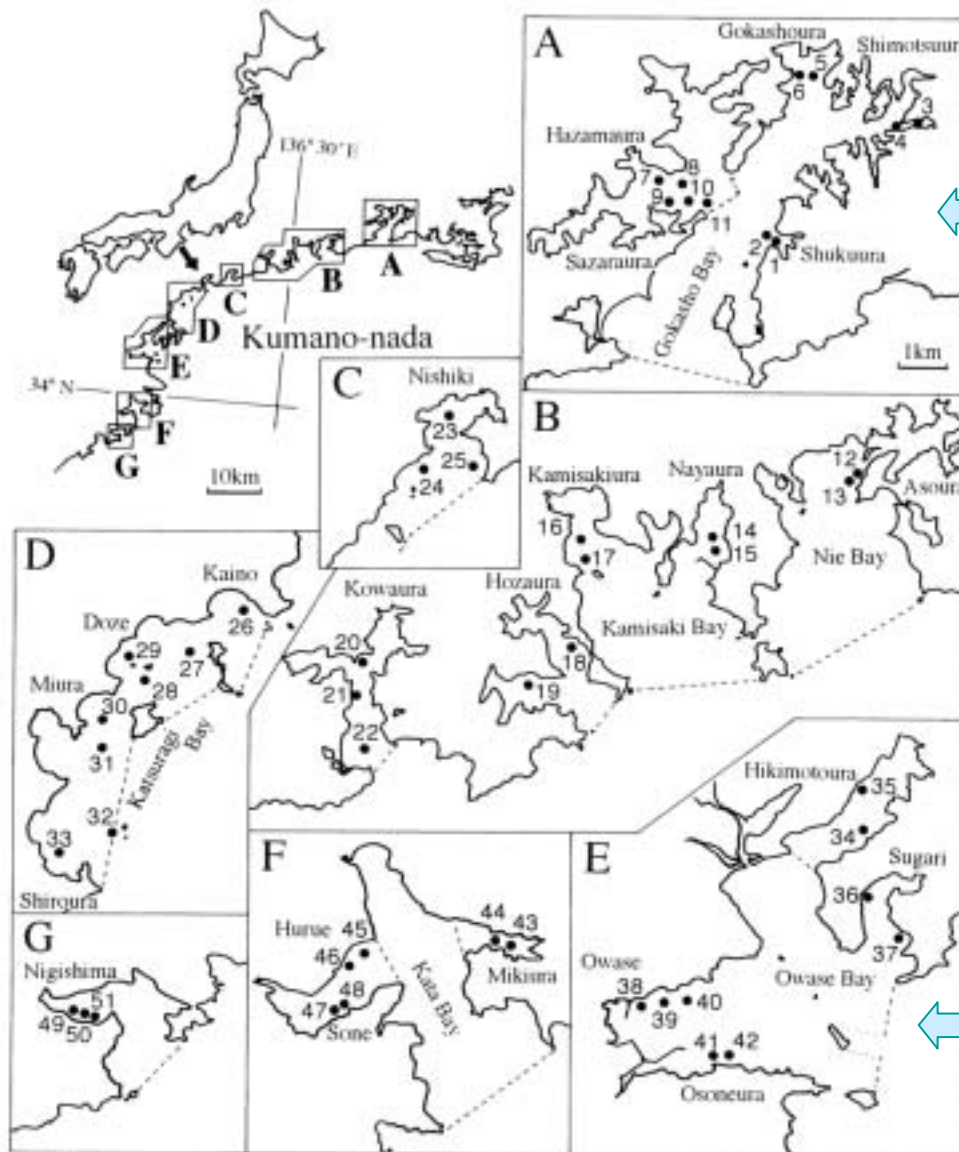
$$V = \frac{(\sqrt{W_0 - W_s} - \sqrt{W - W_s})(284 - 4.03T) - 0.048T - 0.27}{h}$$

time-averaged
current velocity

immersion period

water temperature

Field survey

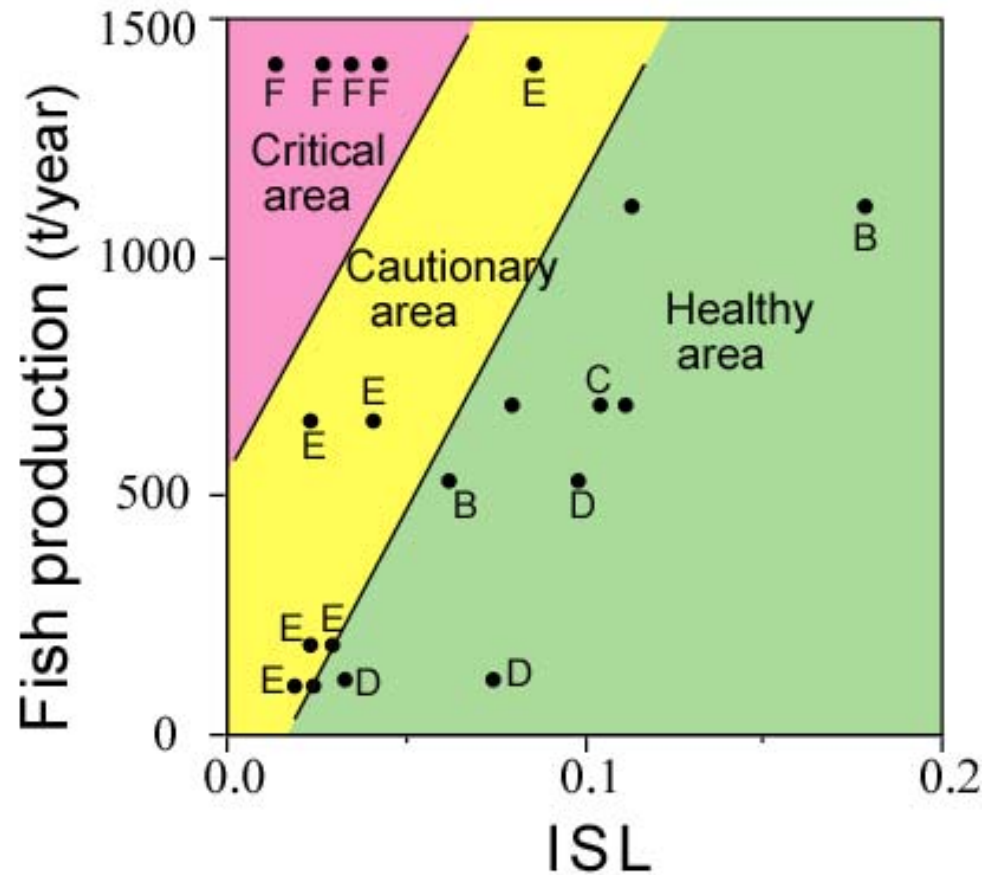


Gokasho Bay
11 stations

Current velocities at
20 fish-farm sites
were estimated, and
ISLs were calculated.

Owase Bay
9 stations

Distribution of macrobenthic assemblages in the gradients of fish production and ISL

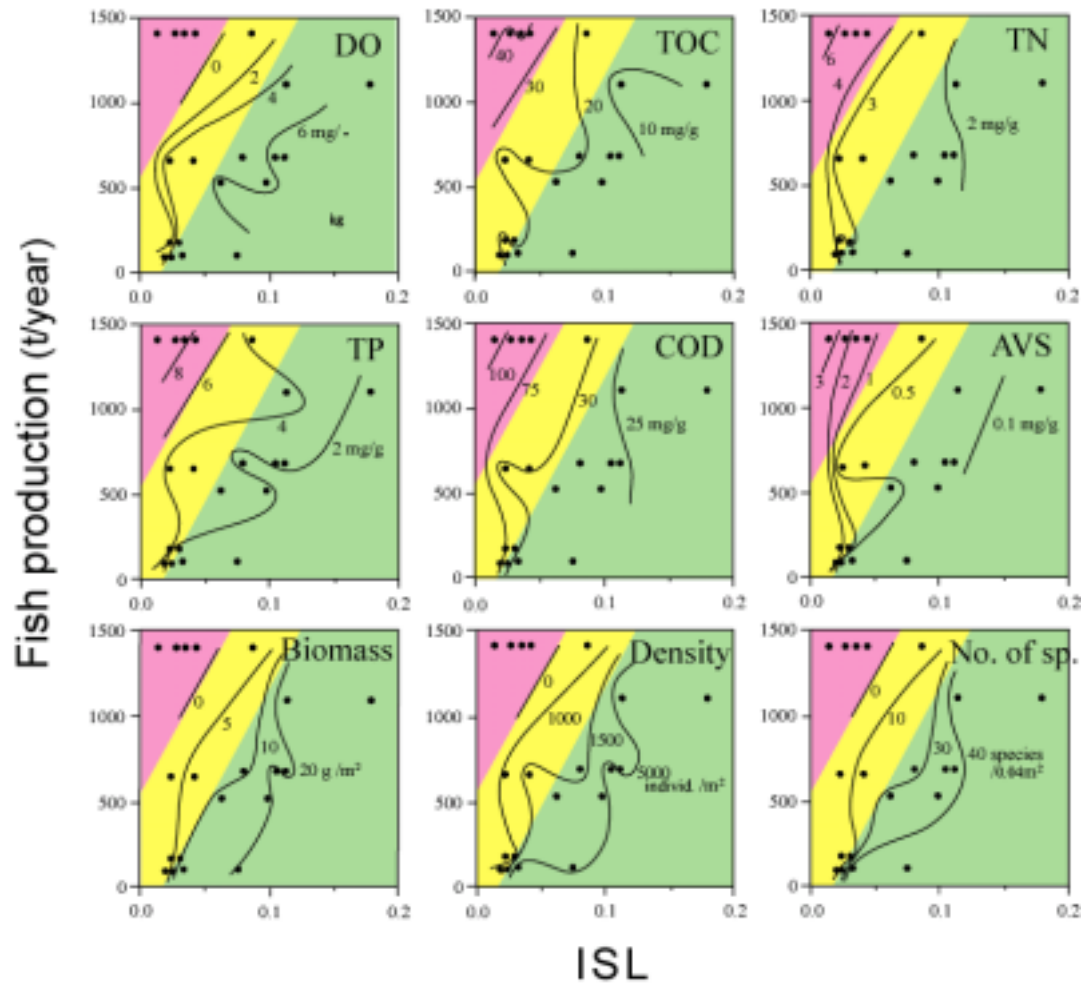


Three groups are arranged regularly in the gradients of fish production and ISL, indicating that **ISL** is a good index to assess the assimilative capacity of fish farms.

Isopleths of abiotic and biotic factors

We can draw isopleths of abiotic and biotic factors in a grid of ISL vs fish production, suggesting

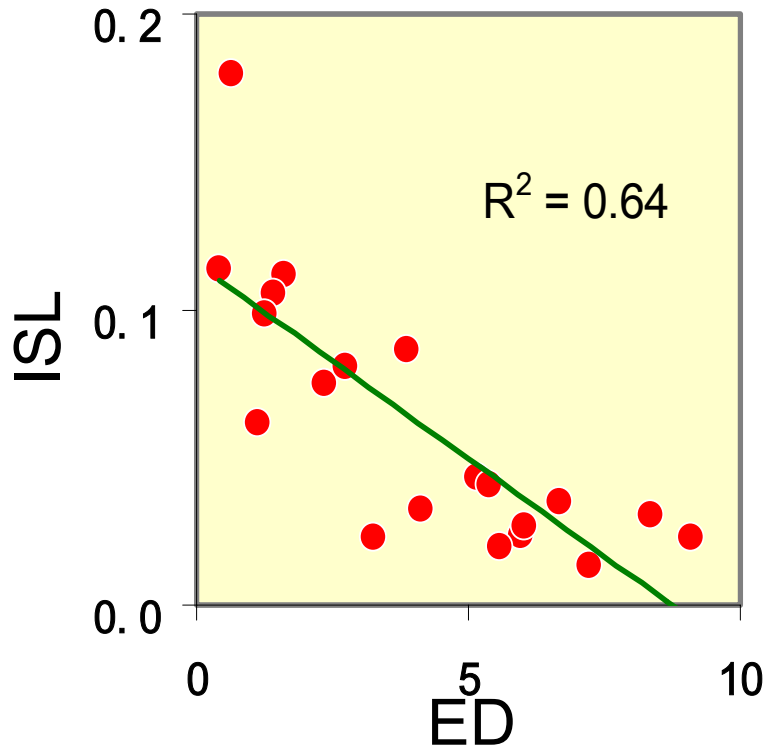
★ the variation of these factors is attributable to the area's bathymetry and water flow as well as organic input, and



★ threshold values of the environmental factors that classify environments into healthy, cautionary and critical conditions can be estimated.

Benthic components	Cautionary condition	Critical condition
Sediment		
TOC (mg/g)	> 20	> 30
TN (mg/g)	> 2.5	> 4
TP (mg/g)	> 4	> 6
COD (mg/g)	> 30	> 75
AVS (mg/g)	> 0.5	> 1.5
Macrobenthos		
Biomass (g/m ²)	< 10	0
Density (/m ²)	< 1500	0
No.of sp. (/0.04 m ²)	< 20	0

Comparison between ED & ISL



index	device	simplicity	generality
ED	chart	⊙	△
ISL	plaster ball	○	⊙

- ★ ED is effective for comparison of environments among neighboring fish farms under similar oceanographic conditions.
- ★ ISL incorporates direct factors that control the waste dispersal and oxygen supply. ISL can be of a wider application to assess the suitability of fish farms.

Advantage of plaster balls

Advantages of using plaster balls are

- ★ the device is easy to construct with readily available materials at a low price,
- ★ fish farmers can estimate the current velocity easily and simultaneously at many stations.

The use of plaster balls will be an effective and pragmatic approach to estimate the assimilative capacity of fish farms.

Summary

Based on an idea that location of a fish farm in a bay, bathymetry and current velocity determine the assimilative capacity, we proposed two indices (ED & ISL).

Environmental conditions can be explained in the gradients of fish production and ED/ISL.

ED & ISL are convenient indices that fish farmers can evaluate their own farms through a chart and plaster balls.



Thank you...